SD Department of Environment & Natural Resources
Watershed Protection Program
Total Maximum Daily Load

Elm Lake Watershed, Brown County, South Dakota
January, 1999

This TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by the US Environmental Protection Agency. The 1998 303(d) Waterbody List identified Elm Lake as impaired by a measure of Trophic State Index (TSI) which serves as an indicator of the trophic condition of the lake. A TMDL for total phosphorus has been developed and is supported below.

TMDL Summary Table:

Waterbody Name	**Elm Lake**
Hydrologic Unit Code (HUC)	10160004
TMDL Pollutant	**Total phosphorus**
Water Quality Target	N:TDP > 7.5 (averaged over one growing season)
TMDL Goal	60% reduction in total phosphorus input
303(d) Status	1998 303(d) Waterbody List, Priority 2, Page 21
Impaired Beneficial Uses	Domestic water supply; immersion recreation; limited contact recreation
Reference Document	Phase I Watershed Assessment Final Report Elm Lake Brown County South Dakota (SDDENR, 1998)

I. Executive Summary:

- ***Waterbody Description and Impairments***

Elm Lake is a reservoir on the Elm River located in northwest Brown County in northeast South Dakota. The total watershed for Elm Lake is approximately 165,240 acres. This includes 59,520 acres that drain into Pheasant Lake, another reservoir on the Elm River located approximately 4 miles north of Elm Lake.

Elm Lake provides drinking water for the city of Aberdeen. The city uses the lake as a storage reservoir for dry periods and has the legal right to the top 12 feet of the pool below the crest of the dam. Water can be released from the lake through draw-down tubes in the earthen embankment. After release, the water flows down the Elm River approximately 30 miles to where the city of Aberdeen pumps the raw water into the water treatment plant. Other beneficial uses of Elm Lake are warmwater permanent fish life propagation, immersion recreation, limited contact recreation, wildlife propagation and livestock watering and irrigation.

Results of the Elm Lake Watershed Assessment Study indicated that Elm Lake receives excessive nutrients but a relatively low sediment load from the tributaries (approximately one acre-foot a year). Erosion from the shoreline is adding sediment to the lake and is, in turn, reducing Secchi disk measurements. The sediment in the water column is colloidal. The densities of colloidal particles do not show up well in laboratory analysis, so the concentrations of suspended solids expressed in mg/L are not inordinately high. Although algae and chlorophyll *a* production can be quite high in Elm Lake (140 mg/m^3), the colloidal particles in the water column appear to limit sunlight penetration of the water which limits algae growth.

- ***Stakeholder Description***

The Brown–Marshall Conservation District was the local sponsor of the Elm Lake Watershed Assessment project. Elm Lake was listed as a priority of the Section 319 Nonpoint Source Pollution Control Program for South Dakota. Funds for the project were obtained from Section 314 Clean Lakes Program funds administered by the Environmental Protection Agency (EPA) and granted to the State of South Dakota. The 30% local match needed for the project was provided by the conservation district, the city of Aberdeen and Brown County. Table 1 lists the participants and stakeholders during the assessment project.

Table 1.

US EPA Clean Lakes Program	City of Aberdeen
Brown Marshall Conservation District	Brown County
McPherson Conservation District	ND Dept. of Health & Cons. Lab. Services
James River Water Development District	SD GF&P
Natural Resources Conservation Service	SD DENR
US Geological Survey	

- ***Intent to Submit as a Clean Water Act Section 303(d) TMDL***

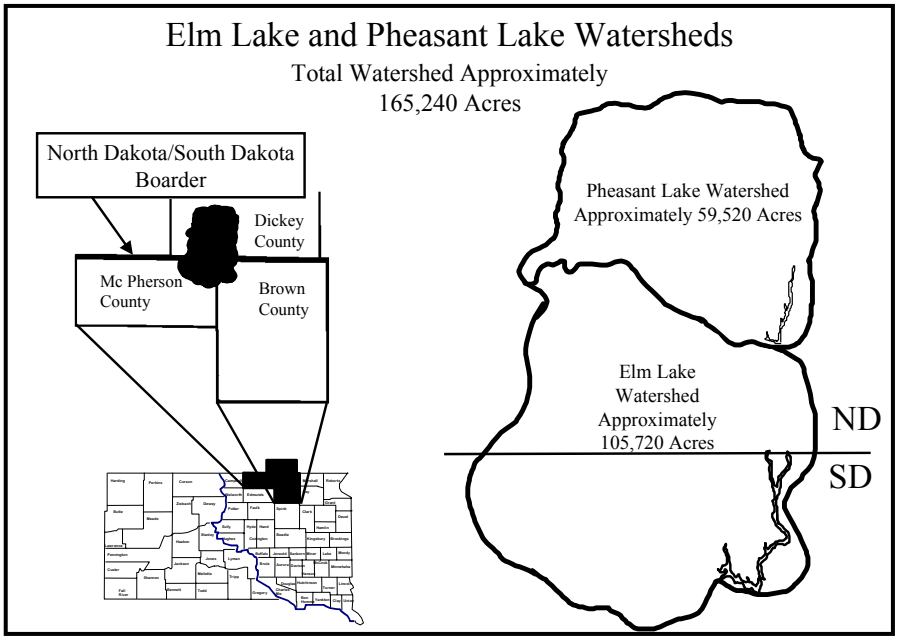
In accordance with Section 303(d) of the Clean Water Act, the South Dakota Department of Environment and Natural Resources submits for EPA, Region VIII review and approval, the phosphorus total maximum daily load (TMDL) for Elm Lake as provided in this summary and attached document. This TMDL has been established at a level necessary to meet the applicable water quality standards for nutrients with consideration of seasonal variation and a margin of safety. The following designated use classifications will be protected through implementation of this TMDL: domestic water supply, immersion recreation, and limited contact recreation.

II. Problem Characterization:

- ***Waterbody description/Maps***

Elm Lake is located within the James River Basin of northwest Brown County in northeast South Dakota (Figure 1). The northern most boundary of the lake is located at the North Dakota-South Dakota border. The reservoir is shaped like a reverse "L" with the north-south fetch approximately 6 miles in length and the horizontal fetch extending west approximately 2 miles.

Figure 1.



Elm Lake Dam was designed and constructed under W.P.A. project #1-544 in 1937 (1978, COE). The purpose of the dam was to serve as a recreation area and drinking water storage for the city of Aberdeen. Currently, South Dakota School and Public Lands hold the easement for Elm Lake Dam. The City of Aberdeen owns the water rights to the top 12 feet of the pool below the crest elevation of the primary spillway. The city has a draw down outlet consisting of two 24-inch cast iron pipes extending through the earthen embankment. Gate valves to each outlet pipe are located in a control house near the crest of the embankment. Elm Lake is considered a high hazard (Category 1) dam because a farmstead is located below the dam embankment.

- ***Waters Covered by TMDL***

  Elm Lake is the benefactor of this TMDL. The main tributary to Elm Lake is the Elm River. The Elm River begins in Dickey County, North Dakota and is first dammed at Pheasant Lake before reaching Elm Lake. Pheasant Lake is located approximately 4 miles north of Elm Lake. The total watershed is approximately 165,240 acres in size. The watershed that drains directly into Elm Lake (not

including Pheasant Lake) is approximately 105,720 acres. The Pheasant Lake watershed covers approximately 59,520 acres.

- ***Rationale for Geographic Coverage***
  The study was initiated during the spring of 1995 after the State of South Dakota received EPA Section 314 Clean Lakes funds for the project. Elm Lake was on the priority list for Section 319 Nonpoint Pollution Control projects. The Brown-Marshall Conservation District was approached and asked if they were interested in participating in a watershed assessment of Elm Lake. The conservation district agreed and secured additional match funds from Brown County and the city of Aberdeen. The 314 Clean Lake grant requirement for match ratio was 70% federal and 30% local. The federal grant totaled $100,000; the local cash and in-kind match totaled $42,857. Funds were used for water quality analyses, equipment and supplies, travel, and wages for the local coordinator. Sampling began during the fall of 1994 and ended the summer of 1996.

- ***Pollutant(s) of Concern***
  Total Phosphorus

- ***Use Impairments or Threats***
  The average Trophic State Index (TSI) for Elm Lake is 66.69, which ranks Elm Lake as eutrophic. There is a large variation between the three parameters used to calculate the TSI. The average chlorophyll *a* TSI was 51.29 (lower eutrophic), the average phosphorus TSI was 88.22 (hyper eutrophic), and the average Secchi disk TSI was 58.36 (eutrophic). It appears that suspended sediments are blocking chlorophyll *a* production even through there is sufficient phosphorus to support nuisance algal blooms. As algae needs only 0.02 mg/L of phosphorus to start growing, Elm Lake averages over 15 times the minimal requirements for algal growth.

  The AGNPS data indicates that from a 25 year event, 240 tons of nitrogen and 72 tons of phosphorus are delivered to the lake while only 169 tons of nitrogen and 45 tons of phosphorus leave the lake. This correlates to a trapping efficiency of 29.5 % for nitrogen and 37.5 % for phosphorus.

  Elm Lake is classified as a drinking water supply for the city of Aberdeen. Reductions in phosphorus levels will eventually lead to a decline in algae and improved water quality. This improvement will result in the improved treatability of the raw water and decrease taste and odor problems. A decrease in trophic state will also improve recreation in and on the lake.

After the N:P > 7.5 target is reached there well may be an increase of available phosphorus, which may lead to an increase in lake productivity as phosphorus is usually the major trigger of algal blooms. With the decrease of phosphorus releases in the watershed, in time, Elm Lake will see a decline in algal blooms and better water quality for domestic use, fishing and immersion recreation.

- ***Probable Sources***

  A total of 53 animal feeding areas were evaluated as part of the study. The AGNPS model uses a scale to rank severity of pollution that ranges between 0 and 100. A rating of 0 indicates that there is zero probability of pollution and 100 indicates the worst possible pollution scenario. Of the 53 feeding areas studied, 10 had an AGNPS rating of 20 or greater and five had a rating of 60 or greater. An evaluation of impact of feeding areas was also performed. When the model was run with the feeding areas with an AGNPS rating of > 60 removed, the total phosphorus loading of Elm Lake was reduced from 143,669 lbs. to 59,445 lbs. (58.6% reduction). The total nitrogen loading was reduced from 480,632 lbs. to 189,880 lbs. (60.4% reduction). The five feeding areas with the AGNPS values > 60 appear to be the primary contributing source of nutrients to the watershed.

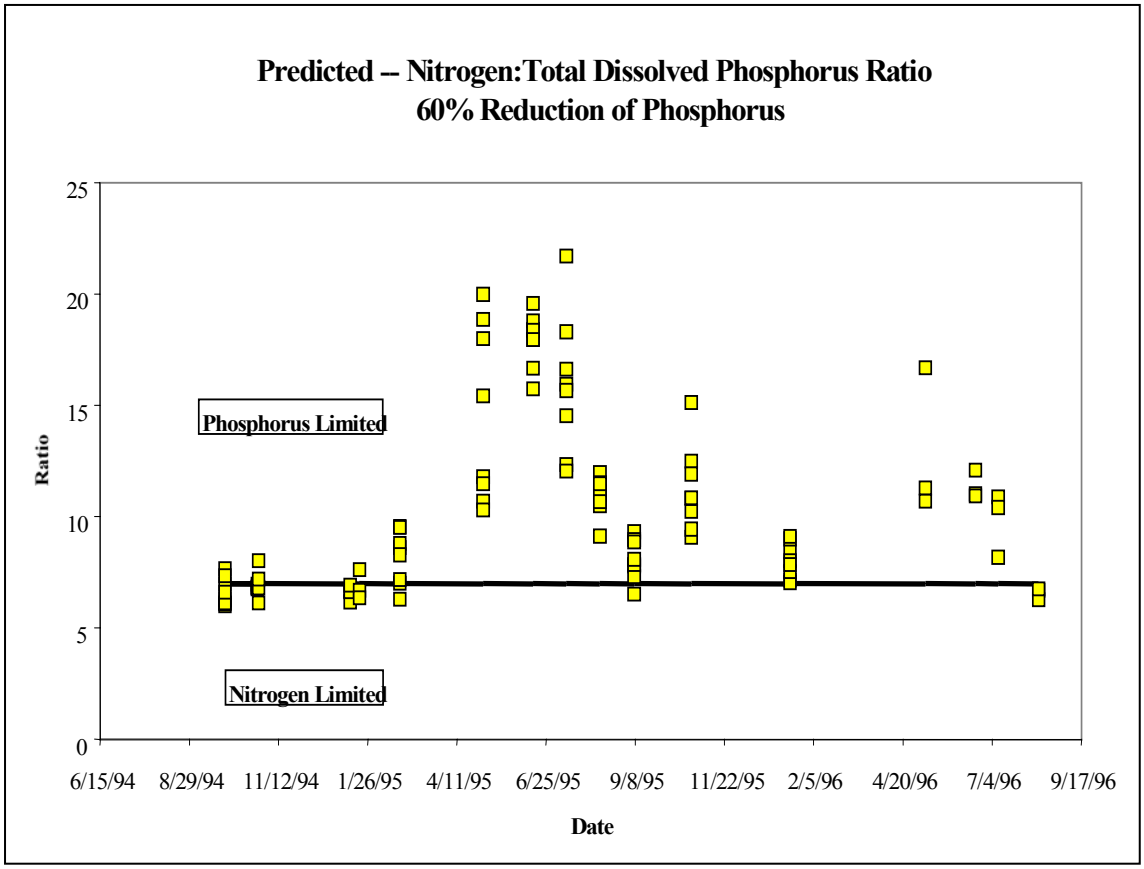
III. TMDL Endpoint:

- ***Description***

  Nutrient concentrations, especially phosphorus, in Elm Lake are excessive. However, due to the light blocking effect of the colloidal suspended solids present, Elm Lake has relatively low chlorophyll *a* production. Typically, a reduction in phosphorus is related to a corresponding reduction in a chlorophyll TSI rating. As shown in Figure 2, there is not a good relationship between phosphorus and chlorophyll *a*. Because of the poor relationship, the primary goal for Elm Lake is to change from being nitrogen limited to being phosphorus limited. To accomplish this, SD DENR is recommending a TMDL target of a total nitrogen to total dissolved phosphorus ratio greater than 7.5. The averaging period for this criterion is one growing season, which typically occurs the months of June, July and August. A TMDL goal of 60% reduction of the tributary phosphorus load will be needed to reach this target.

  The TMDL goal was established based on the AGNPS model which predicted that a 60% reduction in phosphorus input from the watershed is possible by elimination of nutrients released from the feeding areas with a rating > 60. As shown in Figure 2, the lake may reach phosphorus limitation by obtaining a 60% reduction in phosphorus input. Once phosphorus limitation is achieved, a better phosphorus to chlorophyll *a* relationship should result and a reduction of chlorophyll *a* can then be predicted. If the relationship improves, a new target should be set to lower chlorophyll *a* production.

Figure 2.



It is also recommended that an attempt should be made to establish shoreline vegetation around the perimeter of Elm Lake. Littoral vegetation would reduce shoreline erosion and re-suspension of bottom sediments, and provide fish habitat. However, it must be remembered that if sedimentation is reduced, algal growth may increase. Because the success of the vegetative plantings is not predictable, sediment reduction is not targeted.

- ***Endpoint Link to Surface Water Quality Standards***

The TMDL goal of a 60% reduction in phosphorus input to Elm Lake will be defined by a water quality endpoint of a nitrogen to dissolved phosphorus ratio of greater than 7.5 (N:P > 7.5), averaged over a period of one growing season.

The goal will greatly diminish productivity in the lake which in turn will lead to greater support of assigned beneficial uses. This improvement in water quality will ensure that visible pollutants are controlled, more pollutants will not form in

the lake, the growth of nuisance aquatic life will eventually diminish, and treatability of Aberdeen's raw water supply for taste and odor will improve. It will also greatly improve recreation on the lake by increasing aesthetics for swimming and fishing, as well as reduce possible bacterial contamination originating from animal feeding areas.

IV. TMDL Analysis and Development:

- ***Data Sources***

  Data was collected by DENR and the Brown-Marshall Conservation District during the fall of 1994 and the summer of 1996.

- ***Analysis Techniques or Models***

  Hydrologic and water quality data was obtained from 10 tributary monitoring station locations within the watershed as well as inlake sampling sites. Samples collected at each site were taken according to South Dakota's EPA approved *Standard Operating Procedures for Field Samplers*. Water samples were sent to the State Health Laboratory in Pierre for analysis. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved *Clean Lakes Quality Assurance/Quality Control Plan*. This data was used in the nutrient reduction response calculation.

  In addition to water quality monitoring, data was collected to complete a comprehensive watershed landuse model. The AGNPS model was developed by the United States Department of Agriculture (Young et al, 1986) to provide comparative values for forty acre cells in a watershed. The model identifies the possible scenarios for reducing phosphorus in the watershed, targeting the sources for the load allocations.

- ***Seasonality***

  Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, Elm Lake samples were separated into spring (March 13 – May 31, 1995), summer (June 1 – August 31, 1995), and fall (September 1 – November 6, 1995). The Elm Lake watershed experienced heavy snows during the winter of 1994 – 1995. The spring was fairly wet spring and the summer was dry. During the 1995 sampling season, 73 samples were collected in the spring and 6 samples each were collected in summer and fall. The summer and fall samples were collected after heavy rainfalls that occurred in scattered areas of the watershed. Not all sites were sampled during the summer and fall because of scattered rains and intermittent flow.

- ***Margin of Safety***

In order to meet the TMDL goal of a 60% reduction in tributary phosphorus loadings, a nitrogen to dissolved phosphorus ratio > 7.5 will be necessary. This reduction can occur with the control of only 5 of the 53 animal feeding areas identified within the tributaries. The elimination of nutrient releases from the other five animal feeding areas that have an AGNPS rating greater than 20 will result in decrease in remaining phosphorus loads within the watershed by another 5%.

Future monitoring will also help provide a margin of safety for obtaining the TMDL goal. Monitoring will occur during implementation of the recommendations of the assessment project.. This will ensure that a mid-course correction to the N:TDP ratio can be determined, if necessary. Post-implementation monitoring is recommended to observe if the implemented controls are indeed meeting the target. In addition to mid-course and post-implementation monitoring, Elm Lake will be routinely sampled every 3 - 4 years as part of the Statewide Lakes Assessment program. The combination of these various monitoring activities will indicate if the TMDL is achievable or if other controls will be needed.

It is also recommended that a watershed study be completed on the Pheasant Lake watershed while implementation is taking place on the Elm Lake watershed. The analysis should estimate phosphorus reduction targets for Pheasant Lake. The two projects should then be combined to improve the overall water quality of both lakes.

Once phosphorus limitation is achieved with this TMDL, a better phosphorus to chlorophyll *a* relationship can be calculated and a reduction of chlorophyll *a* can be predicted.

V. Allocation of TMDL Loads or Responsibilities:

- ***Wasteload Allocation***

  There are no point sources of pollutants that are of concern in this watershed, therefore the "wasteload allocation" component of the TMDL is considered a zero value. The TMDL is considered wholly included in the "load allocation" component of the TMDL.

- ***Load Allocation***

  The recommended target for improving the water quality of Elm Lake is to change the lake from being nitrogen limited to phosphorus limited. This can be accomplished by reducing the average tributary phosphorus loading to the lake by 60%. According to the AGNPS model, controlling runoff from five feeding areas with rankings over 60 will result in a 58.6% reduction in phosphorus. With the removal of nutrient loading associated animal waste from the five other

contributing feeding areas ranked > 20, an additional 5% reduction in phosphorus should be reached. It is recommended that these ten animal feeding areas be evaluated for potential operational or structural modifications to minimize nutrient releases and surpass the TMDL goal.

- ***Allocation of Responsibility***

  According to the water quality data and the AGNPS model, animal feeding areas are the most likely source of nutrients to Elm Lake. By the use of the AGNPS model, monitoring, reduction response calculations, and best professional judgement, it is determined that the controls proposed below will achieve the TMDL goal of a 60% reduction in phosphorus loads to Elm Lake.

  It is recommended that the five feeding areas with AGNPS ratings greater than 60 have animal waste systems constructed to eliminate nutrient and sediment run-off. Also, the animal waste from the other five confined animal feeding areas with a rating over 20 should be controlled.

  It is also recommended that the croplands targeted by the AGNPS model with slopes greater than 4% and high soil erodibility be field checked and if needed, Best Management Practices including conversion to rangeland or implementation of high residue management plans be applied where applicable.

  Even though no target of improvement is set for turbidity, an attempt should be made to establish shoreline vegetation around Elm Lake. The shoreline vegetation would reduce shoreline erosion, reduce re-suspension of bottom sediments, and provide better fish habitat. Managers should be reminded that the improved light penetration in Elm Lake would most likely cause an increase in algal production until inlake nutrient concentrations are reduced.

  It is also recommended that an extensive watershed assessment be completed on the Pheasant Lake watershed. After completing the watershed assessment, targets should be set for lowering phosphorus in Pheasant Lake. The two implementation projects could then be combined as one project.

  It is recommended that efforts to reduce sediment and nutrients be targeted to the installation of appropriate BMPs on cropland ($\geq$ 4% slope), conversion of highly erodible cropland to rangeland or CRP, improvement of land surface cover (C-factor) on cropland and rangeland and measures initiated to reduce nutrient runoff from animal feeding operations.

  The implementation of appropriate BMPs, targeting identified critical areas, priority subwatershed and feeding areas upon the completion of a field

verification process should produce the most cost effective treatment plan in reducing sediment and nutrient yields from the Elm Lake watershed.

VI. Schedule of Implementation:

The DENR is working with potential sponsors to initiate an implementation project on Elm Lake beginning in the spring of 2000. It is expected that the sponsors will request project assistance during the 1999 fall Section 319 funding round.

VII. Post-Implementation Monitoring:

Once the implementation project is completed, post-implementation monitoring will be required to assure that the TMDL has been reached and improvements to the beneficial uses occur. It is especially imperative that post-implementation monitoring occur to redefine the TMDL once the N:P ratio has been obtained so that a better phosphorus to chlorophyll *a* relationship may be calculated , and a reduction of chlorophyll *a* can be predicted.

VIII. Public Participation:

- ***Summary of Public Review***

The water quality assessment study was initiated during the spring of 1995, after the State of South Dakota received EPA Section 314 Clean Lakes grant funds, as Elm Lake was on the priority list of Section 319 Nonpoint Pollution Control projects. The Brown-Marshall Conservation District agreed to sponsor the project and secured additional match funds from Brown County, the city of Aberdeen and the James River Water Development District. The 314 Clean Lake grant was 70% federal and 30% local. The Section 314 grant totaled $100,000, the local cash and in-kind totaled $42,857. Funds were spent on water quality analysis, equipment and supplies, travel, and wages for the local coordinator.

- ***Project Information and Education Efforts***

The following table summarizes efforts taken to gain public education, review and comment during development of the TMDL:

Table 2.

Public Meetings/ Personal Contact	*Articles/ Fact Sheets*	*Document Distribution*
Pre-project meetings May 25, 1994 **Funding meeting** **Mid-project meeting** **Near-end project meeting**	**November 5, 1995** Aberdeen American News **Spring 1995** I&E Fact Sheet	**October 1998** US EPA Clean Lakes Program Brown Marshall Conservation District McPherson County Conservation District James River Water Development District City of Aberdeen

Public Meetings/ Personal Contact	*Articles/ Fact Sheets*	*Document Distribution*
December 11, 1996 **Final summary meeting** Report distributed; sponsors have yet to ask for final meeting		Brown County NRCS USGS - South Dakota District ND Dept. of Health & Consolidated Laboratory Services SD GF&P SD DENR **January 1999**
Electronic media	*Mailings*	*Public Comments Received*
December 1998 Assessment Summary added to department website **February, 1999** TMDL Summary advertised on department website	**Interested parties** February 17, 1999 **Stakeholders** February 17, 1999 **Daily Newspapers** February 12, 1999	Comments received during project meetings and review of the draft report and findings were considered

IX. Supporting Development Document(s) (attached):

Stueven, G. H. and McIntire, M. September 1998. PHASE I WATERSHED ASSESSMENT FINAL REPORT ELM LAKE BROWN COUNTY SOUTH DAKOTA. South Dakota Watershed Protection Program, Division of Financial and Technical Assistance, South Dakota Department of Environment and Natural Resources, Pierre, South Dakota.